Continuous missing data imputation with incomplete dataset by generative adversarial networks–based unsupervised learning for long-term bridge health monitoring

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Abstract

Wireless sensors are the key components of structural health monitoring systems. During the signal transmission, sensor failure is inevitable, among which, data loss is the most common type. Missing data problem poses a huge challenge to the consequent damage detection and condition assessment, and therefore, great importance should be attached. Conventional missing data imputation basically adopts the correlation-based method, especially for strain monitoring data. However, such methods often require delicate model selection, and the correlations for vehicle-induced strains are much harder to be captured compared with temperature-induced strains. In this article, a novel data-driven generative adversarial network (GAN) for imputing missing strain response is proposed. As opposed to traditional ways where correlations for inter-strains are explicitly modeled, the proposed method directly imputes the missing data considering the spatial–temporal relationships with other strain sensors based on the remaining observed data. Furthermore, the intact and complete dataset is not even necessary during the training process, which shows another great superiority over the model-based imputation method. The proposed method is implemented and verified on a real concrete bridge. In order to demonstrate the applicability and robustness of the GAN, imputation for single and multiple sensors is studied. Results show the proposed method provides an excellent performance of imputation accuracy and efficiency.